JPRS-JST-94-015
25 July 1994

Foreign
Broadcast
Information
Service

JPRS Report

Science & Technology

Japan

New Liquid Crystal Era: Abrupt Change in Market, Technology, Materials and Components

Science & Technology

Japan

New Liquid Crystal Era: Abrupt Changes in Market, Technology, Materials and Components

JPRS-JST-94-015

CONTENTS

25 July 1994

New Liquid Crystal Era: Abrupt Changes in Market, Technology, Materials and Components

Trends and Markets: Expanding Market Applications Lead Way, Technological Innovations in Panels, Parts and Materials

94FE0297A Tokyo NIKKEI MICRODEVICES in Japanese Dec 93 pp 68-75

[Part 1 of three parts by Katsuhiro Nozaki; includes three interviews with corporate executives and a proposed application for LCD; Abstract by Katsuhiro Nozaki and Hiroshi Asakura]

[Text]

Abstract

The liquid crystal industry has leapt into a new era. TFT color markets, panel technology, and parts and materials technology have rapidly changed. If the start-up period of the last four to five years is considered the first generation, the next several years should see a jump into the second generation. New uses such as mobile computing and green PCs will greatly extend the popularity of liquid crystals. Small amusement devices and car navigation will also expand the market base. In order to meet these demands, rapid progress is being made in reducing power consumption and reflectance, and widening the viewing angle. 1W VGA panels are on the way, and technology for widening viewing angle will be available for mass production; a top to bottom viewing angle of 80° will be commonplace. The 2 percent surface reflectance has been achieved. The second stage lines that the major panel manufacturers are betting on will be operating in 1994, and the goal of tripling the productivity of first stage lines has been set. A serious effort is being made to lower parts and materials costs. New technologies are emerging, such as unpolished glass substrates.

Thin, Light, and Energy Efficient Fits Market Needs

The liquid crystal industry has jumped into a new, "Second Generation" phase. Market applications, panel technology, and parts and materials technology have all changed abruptly. In terms of markets, TFT color liquid crystal capabilities fit new trends in mobile computing and "Green PCs," in addition to notebook computers. Car navigation will also expand the market base. Development of panel technology suited for these uses is active. Technology that lowers energy consumption, widens viewing angle, and reduces reflectance are gradually being applied to mass-produced panels. Efforts are being made to lower parts and materials costs in order to have 10-inch panels priced at ¥50,000 by 1995, which will expand markets.

The liquid crystal industry has "indisputably rushed into the second generation" (Mr. Isamu Washizuka, Sharp Executive Director). The period of foundation building for the TFT (thin film transistor) color liquid crystal industry is said to be finished as of 1993. The year 1994 will usher in "a period of rapid progress" (Mr. Hiroshi Shiba, NEC Managing Director). Second generation production lines have started up, and "new applications are mushrooming" (Mr. Koichi Suzuki, Toshiba Liquid Crystal Division Chief), which ensures a trillion yen industry.

The last several years were a start-up period for the liquid crystal industry.[1] If we consider this period to be the first generation for TFT color liquid crystals, the next few years, beginning with 1994, can be called the second generation. This is because markets for new applications, panel technology, and parts and materials technology are changing all at once.

1. Markets, Panel Technology, Parts and Materials Technology Changing

In addition to laptops, notebook computers, and small portable televisions, which are the core market for first generation TFT color liquid crystals, products which newly incorporate the idea of mobile computing are vigorously bringing about market expansion for the second generation (Figures 1 and 2). The base is also greatly expanding, with videocassette recorders that incorporate cameras having TFT liquid crystals, portable video games, and uses in automobiles once car navigation is well established.

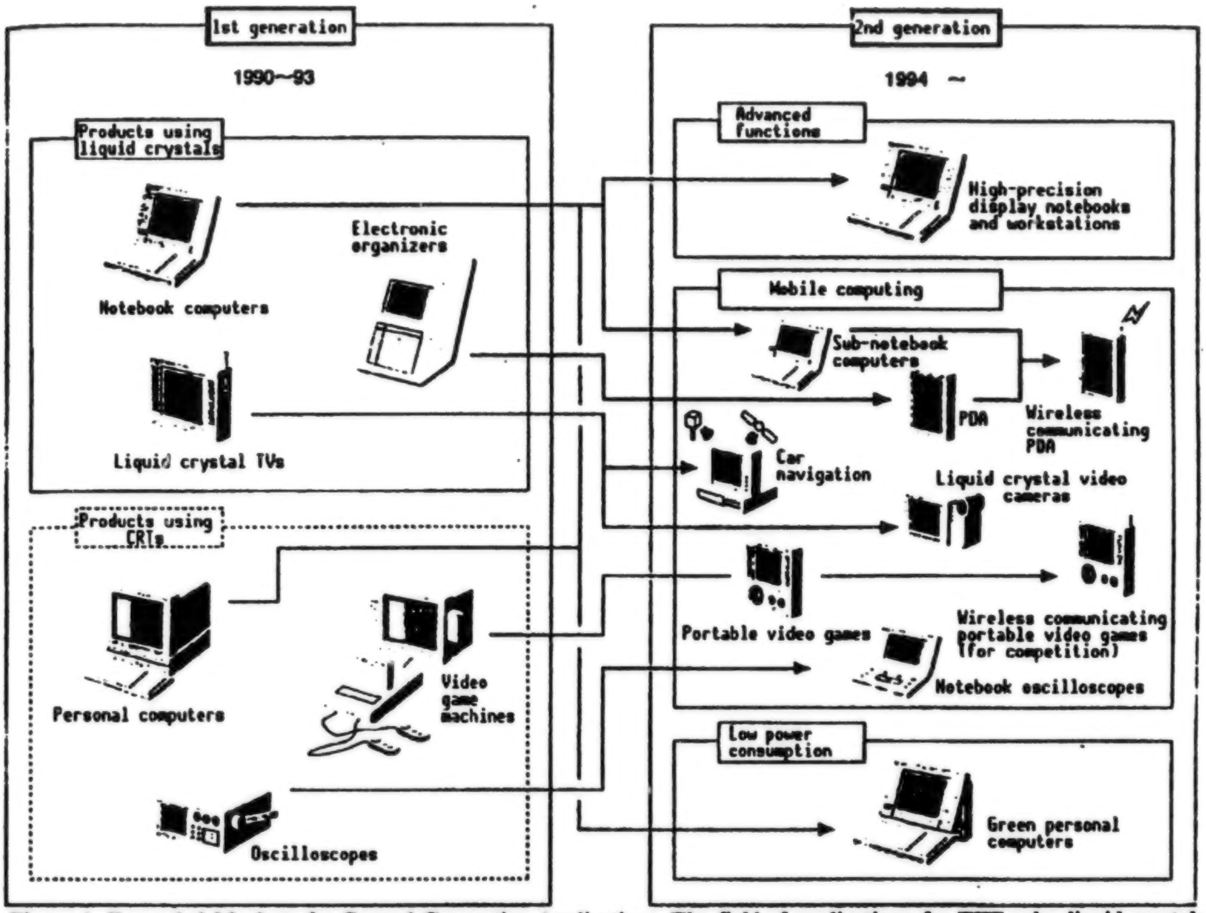


Figure 1. Expanded Markets for Second Generation Applications. The field of applications for TFT color liquid crystals has expanded, because they are thin, light, and energy efficient. Second generation applications give full play to TFT liquid crystal capabilities, such as mobile computing which deals with information "anytime, anywhere, and with anybody," and the "green personal computer," which is the computer-related response to environmental problems.

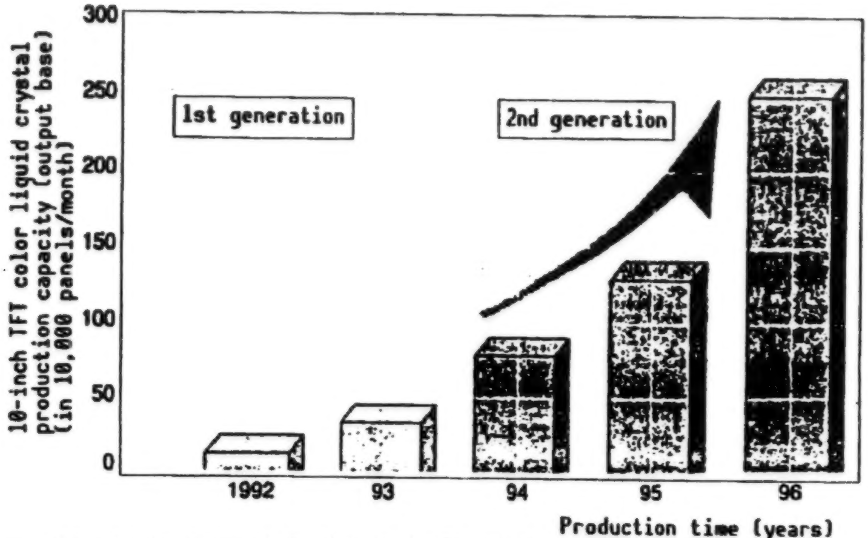


Figure 2. Volume of Production Expands Rapidly in the Second Generation. Second-generation production lines started in mid-1994 will greatly contribute to volume. By 1996, 2.5 million panels/month will be achieved by converting to the 10-inch class, with a production capacity base having 100 percent yield.

Furthermore, in order to conserve energy in the office and to avoid exposure to electromagnetic radiation, a problem with CRTs (cathode ray tubes), desktop computers using TFT liquid crystals have appeared concurrently with the United States's "Energy Star Program." Even the realm of the desktop computer, which was considered to be an unrivaled field for the CRT, will be seeing continued substitution with TFT color.

According to a survey by the Japan Electronic Equipment Manufacturers Association, if TFT color liquid crystals for 10-inch VGA (video graphics array) (640 x 480 pixels) cost ¥60,000 in 1995, the level of demand in that year will approach ¥800 billion.[2] By 1996, TFT color liquid crystals alone will exceed a trillion yen.

Development of panel technology is progressing in order to improve portability and readability as well as mobility; applications for production are beginning (Figure 3). Reduced power consumption is being pursued for portability, and a wider viewing angle and lower reflectance are being pursued in order to improve readability.

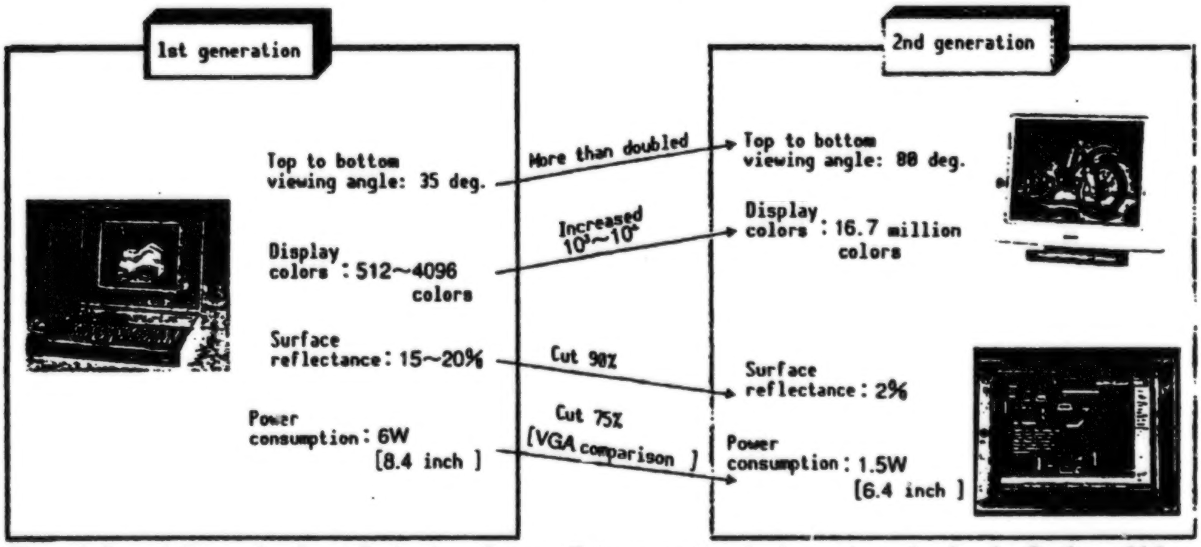


Figure 3. Second Generation Panel Technology. Energy efficiency, a wider viewing angle, and reduced reflection, which are essential in the second generation, are making progress. Full color, which considerably enhances the power of expression, is by necessity advancing. Compared to the first generation, the top to bottom viewing angle has more than doubled to 80°, VGA power consumption has been cut 75 percent, to 1.5W, and surface reflectance has been cut 90 percent, to 2 percent.

Panel makers will begin second-stage lines for actual production in 1994 in response to expanding markets (Table 1).

Table 1. Latest Investment By Panel Makers for the Second Generation

Every firm's new line will start up beginning in 1994 through 1995. Here, representative production lines are shown. Second Generation lines use large substrates of 360x465mm^2 for the mother glass. Four 10-inch class panels can be taken from this. Some makers have plans for enlarging the substrates, as Sharp has already done. *Note: figures for Sansei Electronics are estimates.*

	Sharp	NEC	DTI	Hitachi	Hoshiden	Fujitsu	Goldstar	Sansei Electronics
Value of Investment (billions of yen)	40	30 (Akita), 35 (Kagoshima)	30	30	20	39	43	40
Plant location	Mie Plant	NEC Akita, NEC Kagoshima	DTI Himeji	Mobara Plant	Not yet determined	Fujitsu Yonago	In Korea	
Construction Start Time	January-March 94	Now under construction (Kagoshima)		Now under construction	94-95	Now under construction	September 93	Summer 94
Operation Start Time	Fall 95	Dec 94 (Akita), Beginning of 94 (Kagoshima)	June 94	Latter half of 94	During 95	March 94	95	First half of 95
Increase in Production Volume When Operations Begin (in thousand panels/month)	100	50 (Akita), 40 (Kagoshima)		30	Not yet determined	1.5		
Increase in Production Volume During Full Production (thousand panels/month)	200	120 (Akita), 90 (Kagoshima)	200	110	Not yet determined	100	500	500
Mother Glass Size (mm^2)	500x600	360x465	360x465	360x465	Not yet determined	300x400	360x465	360x465
Number of 10-inch class panels obtained	6	4	4	4	Not yet determined	2	4	4

Lowering the cost of the panels produced will mean that reducing parts and materials costs is essential, in addition to raising line productivity and yield. These costs, which have been difficult to reduce, will finally begin to drop in 1994 (Figure 4).

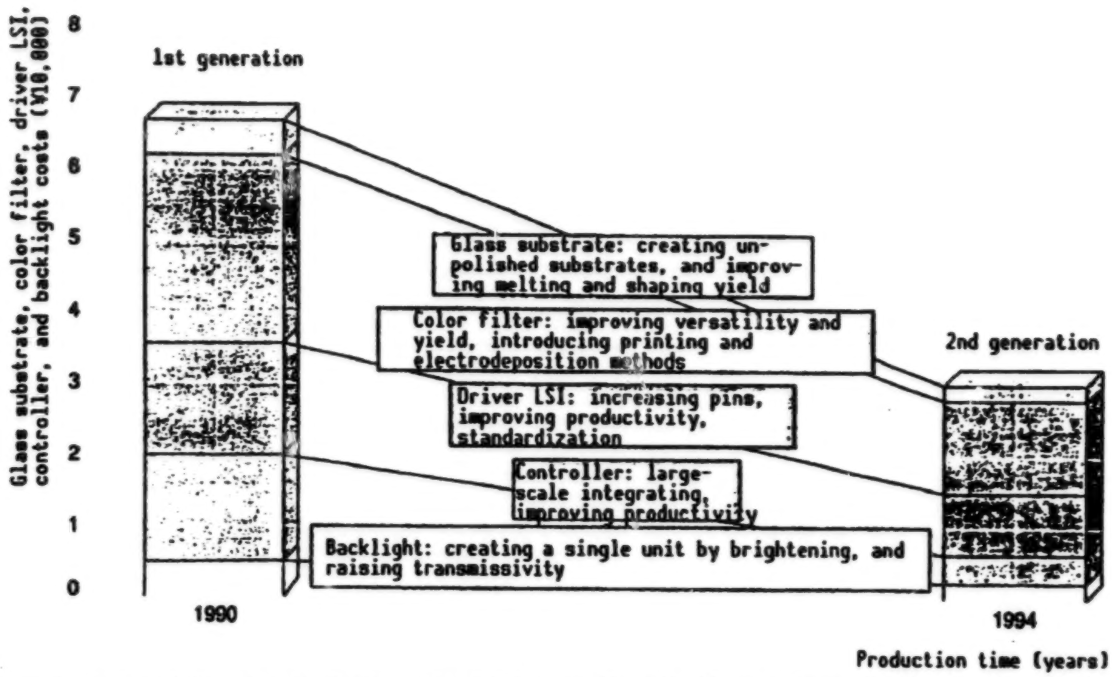


Figure 4. Parts and Materials Technology That Will Lower Costs for Second Generation Panels. Compared to the initial stage of the first generation, the cost of parts and materials has dropped more than half. Cost reductions are planned by adopting new technologies for parts and materials. Unpolished glass substrates, the introduction of color filter printing methods and electrodeposition methods, and a single backlight unit have been very effective.

2. Liquid Crystal Markets Opened by Mobile and Green Personal Computers

Computers that can be used "anytime, anywhere, and with anyone" will be opening a big personal-use market. These machines can be seen as concrete examples of actual mobile computing, and would not be popular without color liquid crystal panels, which gives them richness of expression and the thinness, lightness, and energy efficiency for portability.

The current direction in enhancing the portability of personal computers is defined by the appearance of sub-notebook PCs, which are notebooks made even smaller. IBM Japan will be producing "ThinkPad 220" this May, which uses a 7.7-inch VGA STN (super twisted nematic) monochrome liquid crystal. This enables a "high-function PC that is truly portable" (Mr. Chikara Maruyama, IBM Japan Information Systems Director).

The "Windows" operating system and applications for desktop models can, of course, be used as is with these PCs (personal computers), and an office environment can be replicated anywhere. The liquid crystal panel is slightly smaller than the 10-inch panel currently used. Within the 10-inch class, Sharp's 8.4-inch panel can be applied in sub-notebook models as is.

PDAs (Personal Digital Assistants), which are an extension of electronic organizers, began to enter the market in 1993. Apple Computer Inc. has had a favorable response to its "Message Pad,"[3] with several thousand orders per week since it went on the market in August. The PI-3000 produced by Sharp could be considered a portable computer meant for everyday use. At ¥65,000, it is inexpensive compared to existing products, and is in the same price range as high-end system organizers.[4] It comes equipped with an infrared data communication function as well, although it can only be used over short distances.

Only STN monochrome displays are used in these PDAs. For those used to an office environment with advanced color capability, it is clear that "the screens will leave something to be desired" (NEC Personal Computer Sales and Promotion Chief Mr. Katsuichi Tomita). If cost concessions can be made, then "TFT color will advance into portable information devices too" (Sharp's Washizuka).

Furthermore, the "Green PC" movement, which takes office energy conservation and environmental preservation into consideration, has been a driving force for substituting TFT color liquid crystals for the CRTs of desktop computers. This trend "will grow little by little, and will spread the world over" (IBM Japan Information Systems' Maruyama) through government direction. This is yet another typical market example that demonstrates the true value of liquid crystal panels. In addition, new

proposals are emerging which will thrust liquid crystals into the desktop market (given in detail on pp 74-75).

3. Outdoor Applications Using New Technologies

The demand for outdoor mobility is increasing in the entertainment field as well. Here, the demand for color has been strong from the very beginning. The content of the information transmitted differs from that of PDAs, which primarily use letters; the object is to make pictures and graphics entertaining. In addition to portability, moving, full-color displays are required, and on these points TFT liquid crystal color has advanced more than in the PDA field.

The "Liquid Crystal ViewCam" produced by Sharp is loaded with new technology intended for real outdoor use. One feature is an anti-reflection treatment[6] on the screen surface, which prevents the reflection of outdoor light by means of a multilayered film. The current anti-glare treatment[7] used in OA (office automation) is "inadequate in strong sunlight" (Sharp's A1176 Project Team Chief Mr. Yoshio Okano). In addition, a high intensity, energy efficient semi-hot tube is used as a backlight lamp. A Ushio Inc. product is being used.

An actual car navigation market has also appeared. Although the size of the market in 1993 is 150,000-160,000 units per year, it is rapidly growing, to "nearly 500,000/year by 1995, and one million/year by 2000" (Matsushita Communication Industrial Co). Navigation systems are meant for use within vehicles, but because displaying map information requires detailed color, TFT color liquid crystals will be used.

Although only one's own vehicle position can be recognized on the screen at the present time, a variety of services can be supplied along with the infrastructure for a traffic information system like VICS[8] (vehicle information and communication system). In addition to being a breakthrough in navigation functions, market growth is expected.

By merging with portable telephone networks, personal data communications is possible, and cars can become "moving offices" (Mr. Susumu Nakata, Sales and Business Department Chief, Matsushita Communications Automobile Equipment Division). The effects of market expansion for TFT color liquid crystals are considerable, due to expectations for development of information systems that perform personalized uses.

4. Progress in Technology for Portability and Reduced Costs

Panel technologies suitable for marketing include reducing energy consumption of VGA panels to 1W and enabling outdoor use of VGA panels through a 2 percent surface reflectance (described in detail on pp 76-82, "Power Consumption to 1W; Mass Production of a Wider Viewing Angle"). Items with a top to bottom viewing angle of 80° are being mass produced, and a wide viewing angle is now taken for granted.

From 1994 on, the major panel makers will be starting second stage production lines (refer to the separate articles on pp 71-73). Compared to initial lines, productivity will triple. The mother glass has been enlarged, and processing capacity of production facilities has risen tremendously.

In order for panels in the 10-inch class to be priced at ¥50,000 by 1995, progress has been made in lowering the costs of parts and materials, which were resistant to cuts in 1991-93, by more than 20 percent each year. Parts and materials manufacturers are busy with new technologies that can lower costs in their respective fields (discussed in detail on pp 83-87, "Technologies for ¥50,000 Panels Cropping Up, Such as Unpolished Glass"). By mid-1994, application for mass production will begin.

TFT Leaps Into Second Generation; Reflecting-Type Color Reaches Market by 1996: *Conversation with Sharp Executive Director Isamu Washizuka*

Liquid crystals have already entered the second generation. TFT color liquid crystals were slowly fostered during the first generation beginning in 1988, aided by STN liquid crystals. After that, TFT took a giant leap forward, and its uses expanded once it was considered not simply a part, but a vital component of products (Figure A).

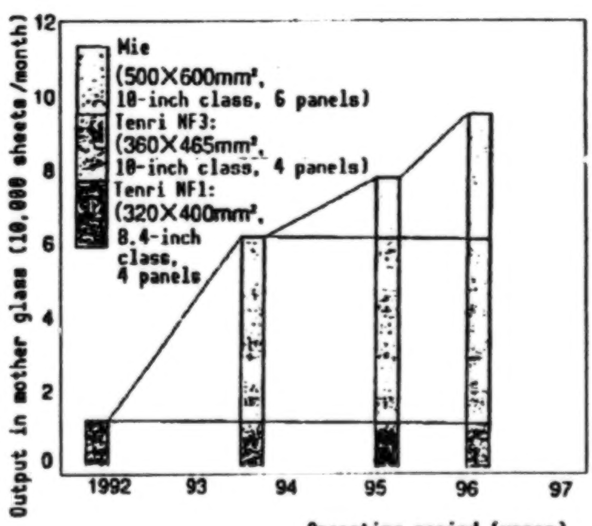


Figure A. Sharp's TFT Color Liquid Crystal Production Plan. Sharp's newest plant, the Mie Plant, will start up by Fall 1995. The value of the investment is ¥40 billion. Six 10-inch class panels from 500x600mm² size mother glass is intended. The output base will be 16,000 sheets/month immediately after start-up, with aproduction capacity of 35,000 sheets/month by 1996. The production capacity of all lines combined will be nearly 100,000 sheets/month.

The market for TFT will exceed ¥700 billion by 1996. Seventy percent of this will be in VGA and half VGA (320 x 240 pixels). The cost in the 10-inch class will definitely be ¥50,000 at the end of 1995 through 1996, and it is estimated that 10 million units will be sold in that period.

The liquid crystal industry is putting a great deal of energy into two trends in order to prepare for the 1996 market. The first is developing substitutes for CRT monitors larger than 10.4 inches. There is a movement in Europe and the United States towards promoting energy conservation in OA equipment, and the importance of liquid crystal monitors for desktop computers is plain. Because of the possibility of both VGA and XGA (extended graphics array) being necessary, ensuring a complete product line of XGA panels is important.

The other trend is developing reflecting-type color for portable computer terminals such as PDAs. In order to ensure portability, it is necessary to set energy consumption at mW units without using a backlight. This requires internalizing a low-temperature polycrystalline Si driver. This will be used in 6-7 inch VGA and half VGA panels; TFT will be the most likely candidate in this field as well.

Both High Quality and Low Costs By Making the Most of LSI Technology: *Conversation With NEC Managing Director Hiroshi Shiba*

The TFT color liquid crystal is one of the biggest products of the last several years, and has a bright future. Until 1993, the foundation of the business was being built, but stabilization and expansion are planned for 1994 (Figure B).

We are moving forward aggressively to make advances in color and in turning PCs into notebooks. The Kagoshima Second Stage line was taken apart three months ago, and will be operating in December 1993. By 1996, a total of ¥110 billion will be invested, and an output base of 170,000-180,000 panels per month is planned.

The next move will be developing liquid crystal displays (LCDs) for AV (audio-visual) equipment using analog full color technology. Because LCD technology is still being refined, panels for OA equipment have become expensive. From now on, the video field, which includes multimedia, will be developed. For example, 6.5-inch VGA panels can be used not only for sub-notebook computers, but for high definition personal television sets as well.

Basically, cost reductions can coexist with pursuit of the highest quality picture, by making the most of the LSI technology that has been fostered up to now. In order to do so, panels must have the simplest structure possible, and the burden of improving picture quality must be placed on LSI. Because LSI costs are determined by chip size, costs can be reduced by making them smaller, no matter how high the capacity. Although relying on parts puts us side by side with other companies, I believe that any number of devices can be made, because LSI is such a strong field.

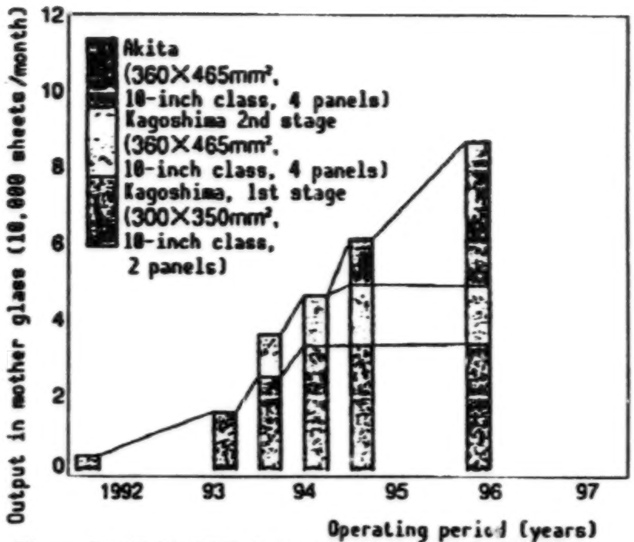


Figure B. NEC's TFT Color Liquid Crystal Production Plan. NEC is constructing two bases for a line that corresponds to a second stage, using a 360x465mm² mother glass substrate. These are the NEC Kagoshima Second Stage line and NEC Akita. Investment amounts to ¥35 billion and ¥30 billion, respectively. Kagoshima will start up at the beginning of 1994, with Akita starting at the end of the year. With a capacity base of 100 percent yield, orders of 280,000 10-inch class sheets/month will be filled in 1996.

Triple the Productivity With Second Stage Lines; Toward Large 4 Panel Sheets: *Conversation With Toshiba Liquid Crystal Division Chief Mr. Koichi Suzuki*

Liquid crystal panels will respond to new demands beginning in 1994. Second generation lines are starting up, and new markets are emerging (Figure C).

The goal of tripled productivity can be attained with second stage lines. This was proven with a trial production line at the Fukutani plant. Because of this rise in productivity, 1.5 million 9.4-inch panels can be produced in a year on DTI's second stage line. A third stage line that produces large glass substrates will be five times as productive as the first stage line, but will not be operating until 1997 at the earliest. To fill the gap until then, a 2.5 stage line is being built, with glass substrate dimensions being the same as that of the second stage.

The goal of 10-inch, ¥50,000 displays by 1995 is based only on the productivity of the second stage line, and can be reached if the price of color filters drops. In actual fact, the price has not dropped much; nevertheless we intend to purchase these in the future as well.

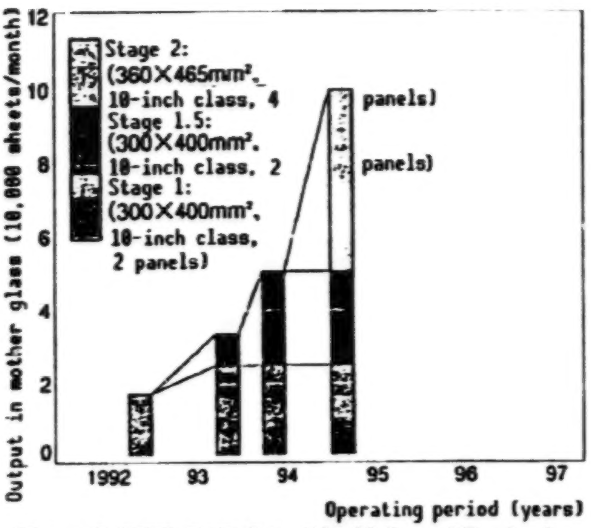


Figure C. DTI's TFT Color Liquid Crystal Production Plan. Display Technology Inc (DTI), a joint Toshiba and IBM Japan investment, has created second stage production lines in the unused space of existing plants at the cost of ¥ 30 billion. Operations will begin in June, 1994, with full production by mid-1995. At this point in time production capacity will be 100,000 sheets per month as the output base for all lines. Because investment in second stage lines is effectively split in two, production capacity is divided, with half in the first part of 1995 and half at the end of 1995. Here, both are lumped together as an increase for the first half of 1995.

As expected, 9.4-inch VGA panels for notebook computers are becoming the standard. But users demand large panels, as shown by the reception to the 10.4-inch size of IBM Corp.'s "ThinkPad." We are looking into the maximum panel size with four panels taken from 360 x 465mm^2, in order to have as large a panel as possible within an A4 size framework.

"Multi-Display System": Proposing a New Use for Liquid Crystal Panels ***Norihiko Tadano, Nomura Research Institute, Technical and Industrial Research Division***

A "display system having flexible expandability in response to software" is being proposed. The goal is to satisfy the demands of users of multitasking operating systems like "Windows."

In a multitasking environment, several applications can be used simultaneously by means of multiple windows. However, in order to do so, a large screen, high resolution display is necessary. The price of this kind of CRT monitor is still high.

Until now, we have been trapped by the fixed idea of one display for one computer. In a GUI (graphic user interface) environment, a display corresponds to a desk. If a number of documents are opened up on a small desk, the work capacity drops. It is better to replace the desk with a large one, but due to the expense, there is no choice but to make do.

The fundamental concept of this system is having a "wing desk" available for holding work. This would be a thin, lightweight liquid crystal display. In this system, work can be done while looking at different windows on different displays at the same time. Items such as a program manager and schedule manager can be continually displayed on the small screen. Word processing and spreadsheets would be displayed in separate windows, and documents and graphs can be created and used while referring to both. A "new area" can be cheaply obtained through replacement with a large monitor.

New technologies are not really necessary for this system. An interface card equipped with several display controllers and a "Windows" display driver are enough; only configuration of a board layout and driver are required. The gigantic AT desktop market would immediately be a new market for liquid crystal panels. Memory and hard disks can be expanded according to need; so to think that displays are not capable of expansion does not make sense. If this system gains acceptance, I believe that a very large market will be opened up.

Editor's note: A more detailed discussion that includes a technical study of this proposal can be found in "Flat Panel Displays 1994" (Nikkei BP edition) and in a report by the Nomura Research Institute that will be published in February.

Footnotes

1. Of the different types of flat panel displays, TFT color liquid crystals came out ahead by 1990, and by 1992 large-scale mass production facilities were established and operating. In 1992, it was recognized that yields of over 50 percent were possible on these large model lines; by 1993 the market had expanded rapidly, centered on notebook computers. This is attributed to the fact that leading liquid crystal maker Sharp's 1993 production value of TFT liquid crystals was ¥ 100 billion, and that a reversal could be seen in the outlook for simple matrix models centered around STN, which were valued at ¥ 75 billion.

2. "Investigative Report on the Electronic Display Industry's Vision for 2000," published by the Japan Electronic Equipment Manufacturers Association, July 1993, pp 1-26.

3. Manufactured by Sharp. An identical product is sold in the United States with the name "ExpertPad."

4. The cost of the deluxe class Bible-sized system organizer sold by Britain's FiloFax is ¥ 150,000. The price range for general high end products is ¥ 50,000-60,000. Ordinary products go for ¥ 10,000-30,000.

5. The series name for energy efficient personal computers developed by IBM Corp. of the United States along the "Energy Star Program" guidelines of the Environmental Protection Agency.

6. A method in which a multilayered film is vaporized onto the liquid crystal module's polarizing plate, which prevents reflections by attenuating the reflected rays of outdoor light.

7. Like anti-reflection treatment, this method prevents reflection of outdoor light, but the surface of the screen is simply roughened, and reflected light is merely scattered. Production costs are therefore low, but its effect on reducing reflecting rays is also low, and there are other drawbacks such as lowered panel transmissivity and reduced resolution.

8. A system promoted by the National Police Agency, Ministry of Posts and Telecommunications, and Ministry of Construction that gives drivers road and traffic information in real time. This includes information on slowdowns, accidents, regulations, and parking. The information is supplied through beacons, FM broadcasts, and teleterminals; receiving requires navigation systems having communication functions. The relevant agencies and enterprises are now in consultation and aiming for setup by 1995.

Panel Technology: Power Consumption to 1W; Mass Production of a Wider Viewing Angle

94FE0297B Tokyo NIKKEI MICRODEVICES in Japanese Dec 93 pp 76-82

[Part 2 of three parts by Hiroshi Asakura; includes three contributed essays from corporate executives]

[Text]

Second Stage Production Lines Set Goal of Tripled Productivity

TFT color liquid crystal panels are rapidly advancing in terms of reduced power consumption, wider viewing angle, and low reflectance, in order to fit the second generation use environment, which emphasized portability and readability. An energy efficient 1.5W VGA panel has been achieved, reaching a level where it can be used on the run. Viewing angle technology that doubles the current viewing angle will increasingly be utilized in mass-produced panels. A reflectance of 2 percent, which is one-tenth the current rate, has been achieved. Mass production lines have achieved the targeted goal of tripled productivity compared to first stage lines. Evaluation of sheet processing equipment that can handle four panel glass substrates has been thoroughly completed, with an 80 percent yield likely.

TFT color liquid crystal panel technology has changed a great deal in response to the second generation. The rise of mobile computing has changed a "fixed environment," in which the place of use is the desktop, to a "moving environment" where the computer is taken along; TFT panels have been the impetus behind improvements in portability and readability in different environments (Figure 1).

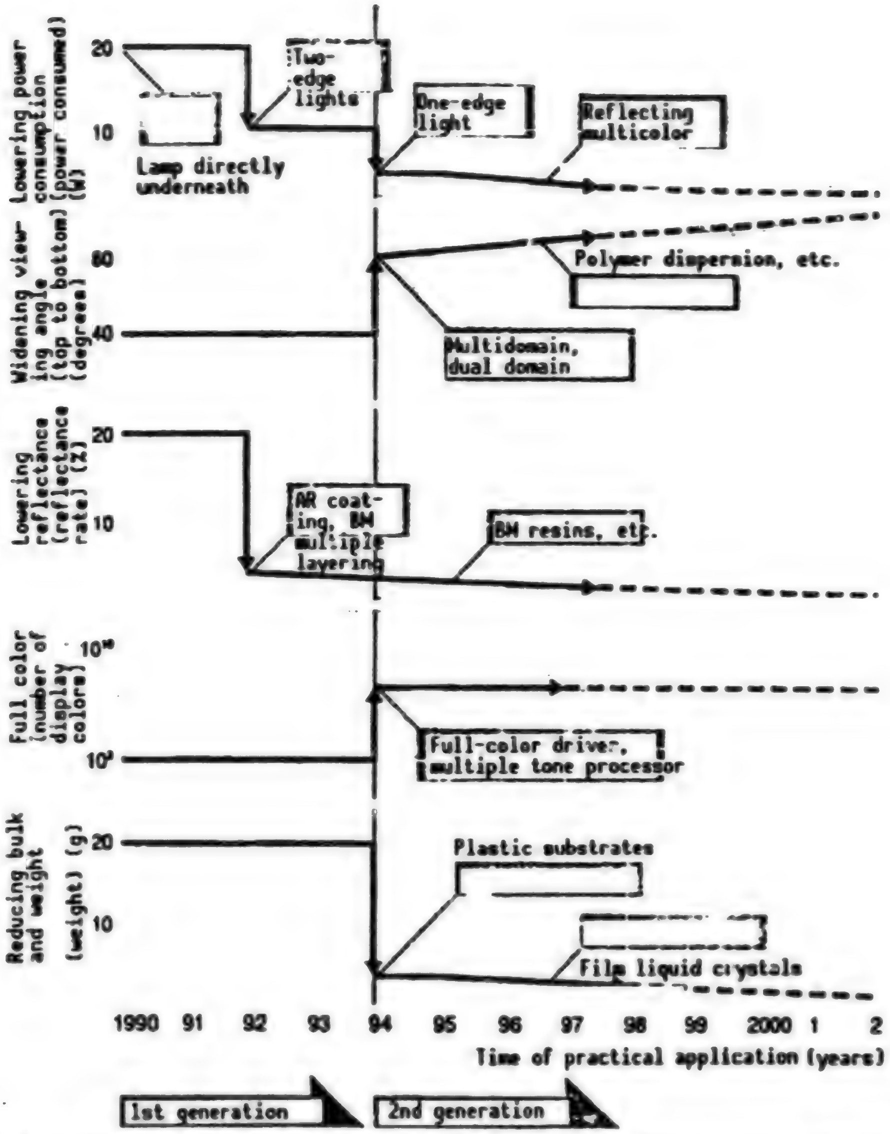


Figure 1. Shifts in Technology Suited for the Second Generation. Plans that stress portability and readability continue into the second generation. The quest to lower the power consumption of TFT color was reached with a 1.5W VGA panel. A viewing angle of 80°, which is twice that of current models, was realized, and will eventually reach the mass production stage. Low reflectance models are being produced with a reflectance rate of 2 percent, which is one-tenth that of current models. Full color technology has arrived, and a trend towards slimmer, lighter models can be seen through use of plastic substrates.

In order to improve portability, work continues on reducing power consumption, in particular on extending the operating time of the battery. The power consumed by TFT panels has been reduced by more than half, by using one rather than two backlights. VGA panels that cut 2W of power are also coming out.

Among improvements in readability, technical innovations for widening the viewing angle and lowering reflectance stand out. All of the panel makers are rushing into mass production of panels with wider viewing angles that are "necessary because of portability, in which the viewing angle changes depending on how the machine is used" (Mr. Masanari Masukawa, Managing Director at Sharp). Beginning in 1994, mass production lines using technology that doubles the viewing angle without increasing the number of processes will start up. Lowering reflectance, especially when the panels are used outdoors, has become a necessary technology. Technology that lowers surface reflectance to one-tenth is being used in new products.

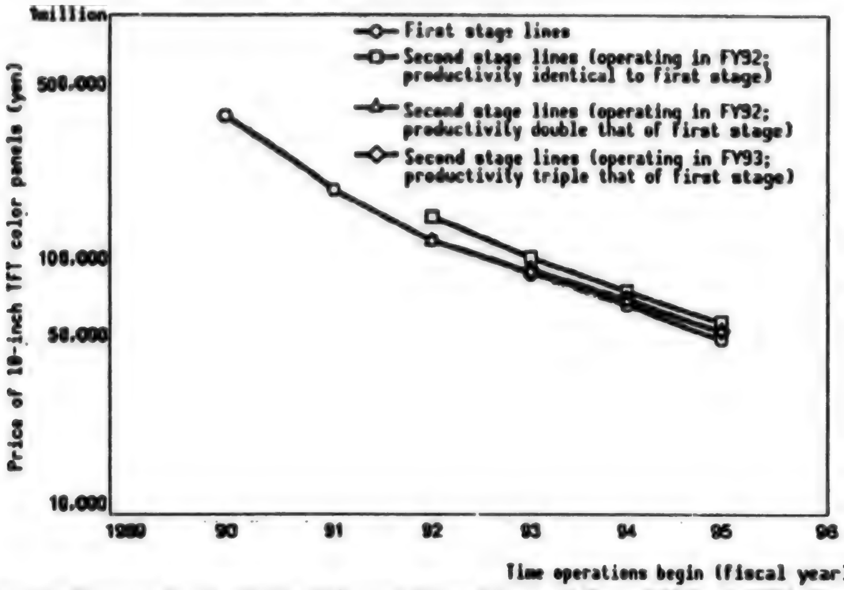


Figure 2. Relationship Between Productivity of Second Stage Lines and Cost of 10-Inch VGA Panels. According to a simulation by this journal, second stage lines operating during fiscal 1993 (by March 1994) must triple productivity in order to reach the industry goal of ¥ 50,000 panels by 1995. Every major panelmaker is expected to be able to reach that goal.

Second stage production lines of the leading panel manufacturers, which incorporate these technologies, will gradually begin operations starting in the first part of 1994 (Figure 2). Productivity will greatly improve so that the industry goal of "¥ 50,000 10-inch VGA panels by 1995" can be met; tripling the productivity of first stage lines is the goal.

1. From a Single Backlight to Reflecting Color

Progress continues in terms of using a single fluorescent tube for the TFT panel backlight, and the power consumed by second generation panels has fallen by more than half. There is now a switch to designs that stress energy efficiency by sacrificing some brightness rather than designs aiming for higher picture quality.

Sharp has lowered power consumption to 1.5W with a screen brightness of $70cd/m^2$ by using both a condensing lens and a film in its 6.4-inch color VGA panels. The percentage of the TFT cell open is 35 percent. Mass production will begin in the middle of 1994. Sharp will increase the percentage that is open to 40 percent in the future, but in order to go lower than 1W, which is common in battery operated reflecting STN monochrome panels, Sharp's Executive Director Isamu Washizuka has ordered "haste in developing reflecting color panels without backlights." "We want to put these to use by 1996, using TFT methods" (Mr. Washizuka).

At the same time, Casio Computer Co. displayed reflecting color panels at the "Electronics Show 93," which was the focus of the show. By using color contrasts that depend on the double refraction effect of STN liquid crystals, colors can be changed depending on voltage size. A 64 x 64 dot matrix display has already been made, and "will be in production in Fall 1994" (Mr. Susumu Mineo, Casio Managing Director). The power consumed is in line with that of STN reflecting monochrome displays.

2. Toward Mass Production of Wider Viewing Angle

From 1994 on, panels with a wide viewing angle will be mass produced. Until now, methods that complicate the production process were applied for some high-grade panels, but the second generation allows for mass production of panels without additional processing (Table 1).

Table 1. Each Company's Wide Viewing Angle Technology

5:1 contrast when viewing angle not specified. [*1]Range without tone reversal. [*2]Product specifications do not necessarily agree. [*3]10:1 contrast. [*4]Developed jointly by Tokyo University of Agriculture and Technology and Stanley Electric. [*5]Patterning of the edge of the opposing electrode by an exposure process is a precondition. [*6]30:1 contrast. [*7]Tektronix (U.S.) has also announced the same.

Method	Orientation Control							Voltage Control	Compensating Plate Only
Item	TN cell multidomain orientation	TN cell random orientation	TN cell orientation division	SH cell enclosed electrode-electric field control	SH cell orientation division	π cell	Polymer dispersion	Capacity coupling, pixel division	
Viewing angle (degrees): left to right	80[*1]	100[*2]	100	100[*5]	100	80[*7]	120	60	70
Viewing angle (degrees): top to bottom	80[*1]	96[*2]	70	100[*5]	100	80[*7]	120	50	30
Contrast (maximum)	100:1 or less	100:1 or less	100:1 or less	100:1 or less	100:1 or less	100:1 or less	100:1 or less	100:1 or less	100:1 or less
Brightness (%) (TN comparison)	100	97	100	100	100	100	33	100	100
Orientation Stability	Equal to TN	Equal to TN	Equal to TN	Slightly inferior to TN	Slightly inferior to TN	Slightly inferior to TN	Equal to TN	Equal to TN	Equal to TN
Factors Increasing Processes	None	None (rubbing is reduced)	Pixel division, rubbing	None (rubbing is reduced)[*6]	Pixel division, rubbing	None	None	Adding capacity, pixel division	None
R&D Organization (Public Display Forum or Conference)	Sharp (Electronics Show '93)[*3]	Tokyo University of Agriculture and Technology[*4] (SID '93)	NEC, Fujitsu, IBM	IBM (EuroDisplay '93), Sanyo (19th Liquid Crystal Forum)	IBM	Tohoku University[*4] (SID '93)	Fujitsu	Hoshiden and others[*5]	Toshiba, IBM

Both Sharp and Sanyo Electric have developed technologies that widen the viewing angle without increasing the number of processes, using existing facilities. Sharp has expanded the top to bottom viewing angle to 80° simply by changing the conditions for the formation process of oriented film material. This technology will be employed in products beginning in Spring 1994 (see the contribution on p 79). Sanyo is adopting a method that widens the top to bottom viewing angle to 100° simply by changing the opposing electrode's mask pattern. These panels will be mass produced in Summer 1994.

Panel reflectance has rapidly dropped to one-tenth in the second generation. Until recently, this was achieved by a highly reflective black matrix and anti-reflection treatment of the polarizing plates. Currently, a black matrix is one layer of Cr, but a two-layer structure of Cr oxide film lowers reflectance. A method that vaporizes inorganic film in multiple layers has been effective in preventing polarizing plate reflection. A way to remove the plate that protects the front has also emerged (see the contribution on p 80). The cost of producing polarizing plates jumps 3-10 times depending on the volume of production, because the multilayer deposition process is a batch method. Development of a coating method for multilayer films will be active from a cost standpoint.

3. Tripling Productivity With Second Stage Lines a Certainty

Second stage lines for TFT panels that begin operating in 1994 will quickly triple productivity. Evaluation of equipment that can handle four 9.4-inch panels is nearly complete, and faith in tripled productivity "has been

proven on trial production lines (Mr. Koichi Suzuki, Toshiba Liquid Crystal Division Chief). Third stage lines will entail creating even larger substrates, with the goal of creating lines that can handle six to nine 10-inch panels (described in detail on pp 81-82).

Wider Viewing Angle While Stressing Mass Production; Doubling Top to Bottom Viewing Angle Through Multidomain Creation: ***Mr. Shigemitsu Mizutori, Sharp Liquid Crystal Division TFT Development Center***

Technologies for widening the viewing angle of TFT color liquid crystal panels that are easily mass produced have been developed, and the goal of practical application by Spring 1994 has been reached. An 80° top to bottom viewing angle, which is twice the current viewing angle, has been realized.

The method recently developed basically uses the same TN (twisted nematic) display mode currently used. Viewing angle characteristics were improved by nonuniform orientation of the liquid crystal molecules, which were always uniformly oriented. This can improve viewing angle characteristics because the dispersion of electro-optical characteristics that are produced by nonuniform liquid crystal molecule direction is visually equalized within 1 pixel. A wider viewing angle can be obtained by planning for uneven orientation of liquid crystal molecules.

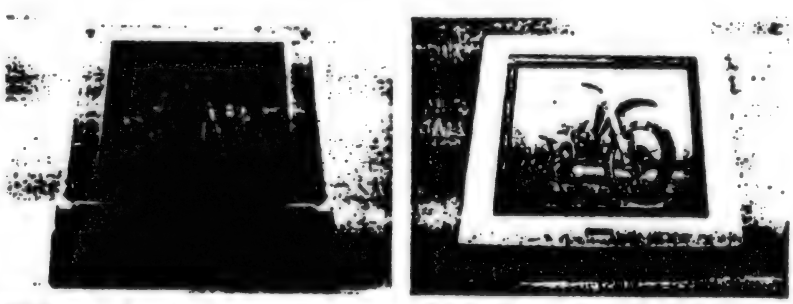
The actual processing uses the current orientation film application process and modifies only the method of regulating materials for pre- and post-processing and process conditions. This method creates an orientation film in which the direction of orientation is not uniform, and makes the orientation of liquid crystal molecules nonuniform. There are no additional processes such as an exposure process, and only one rubbing treatment is done. Because wet processing, which is the cause of contamination, is unnecessary, the increase in production costs is small, and reliability remains high. Furthermore, existing production facilities can be used with very few modifications, and the effect on mass production process training is slight, because process modification is minimal.

Compared to existing products, display capabilities obtained in this way do not fundamentally worsen electro-optical characteristics, but improve only viewing angle characteristics (Figure 4, Table 2). There is no effect on design specifications such as a module's power consumption or operating voltage. The data in Table 2 give an example of the characteristics of TFT panels using this method. By modifying liquid crystal orientation, viewing angles appropriate to use can be obtained.

Table 2. Characteristics of TFT Color Liquid Crystals Using Wide Viewing Angle Technology

Data given are examples of TFT panel features using current wide viewing angle technology; by modifying the layout of liquid crystal orientation, viewing angles suitable for type of use can be obtained.

	Wide Viewing Angle Product	Current Product	Remarks
Contrast	100:1 or less	100:1 or less	Observed from a normal line direction
Response Speed	30 ms or less	30 ms or less	Observed at a temperature of 25°C
Transmissivity	100	100	Current product set at 100
Viewing Angle Range (top to bottom)	+/- 40°	top + 25°, bottom - 10°	Range without tone reversal, with contrast 5:1 or greater
Viewing Angle Range (left to right)	+ or - 40°	+ or - 40°	



(a) Current Product (b) Wide Viewing Angle Product

Figure 4. Comparison of a Current 14-Inch TFT Color Liquid Crystal Product With a Wide Viewing Angle Product

Technologies for widening viewing angle should be loaded on to all TFT panels. It will not greatly increase processing, does not use special materials, and does not cause a drop in quality or reliability. In addition, the technology, which is becoming a standard specification, does not require remodeling of existing lines, which were built at great cost. Which of the various methods currently proposed and pushed towards practical application will become mainstream depends on future research and development. At this point in time, this method has an advantage over other methods.

Surface Reflectance Cut to One-Tenth With AR Treatment; Enables Outdoor Use of TFT Panels:
Hideshige Yakushikawa, Sharp Liquid Crystal Division TFT Development Center

Outdoor readability has markedly improved by reducing reflection and increasing brightness of TFT color liquid crystal panels. They can now be used outdoors even without a hood. The "Liquid Crystal View Cam" probably would not have come about without this technology.

Up to now, incident light would reflect off the interface between the TFT color liquid crystal's front protection plate and the air layer, and off the polarizing plate surface (Figure 5).

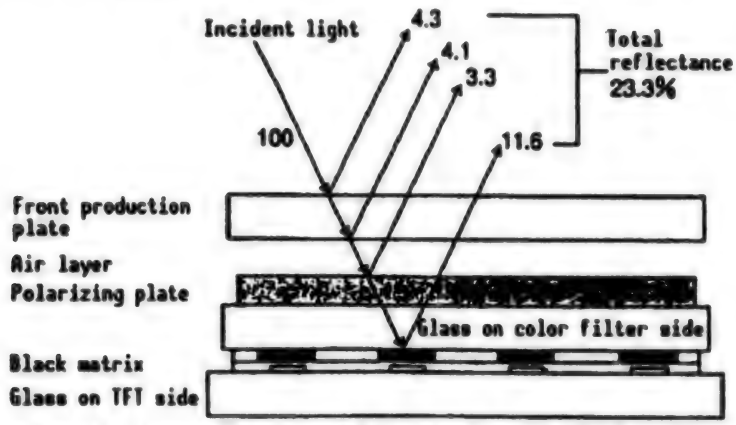


Figure 5. Transmissivity of the Current TFT Color Liquid Crystal Panel. Interfaces between air and both sides of the front protection plate have high reflectance. If the front protection plate is made of acrylic, the sum of the reflectance of the front and back surfaces of the plate is 8.4 percent. Reflection off the polarizing plate surface is 3.9 percent, and off the black matrix is 30 percent.

The light reaching the glass on the color filter side amounts to 44 percent of the light incident on the panel, if the transmissivity of the polarizing plate is taken into account. Because approximately 30 percent is reflected by the black matrix, the reflected light is returned to the display surface once more. The total reflected light that arrives at the display surface, including the light reflected from the respective interfaces, amounts to 23.3 percent of the incident light.

The features of the recently developed low reflection panel (Figure 6) include treating the polarizing plate with a low reflection coating, reducing the reflection off the black matrix, and removing the air layer interface that causes reflection by removing the front protection plate.

The low reflection coating is known as an anti-reflection (AR) treatment, and makes use of the principle that reflected light is absorbed by light interference within the

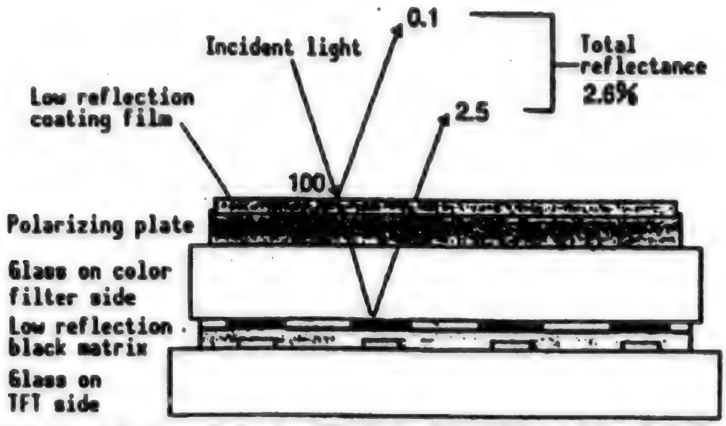


Figure 6. Transmissivity of the Low Reflection TFT Color Liquid Crystal Panel. Reflection off the interface is reduced by omitting the air layer on top of the polarizing plate. Total reflectance can be reduced to 2.6 percent. The next problem to address will be the conspicuous fingerprints caused by the anti-reflection coating. A low reflecting material was substituted for the black matrix.

multilayer film. In panels used for OA, anti-glare treatment is widely used to prevent reflection. Anti-glare treatment simply scatters the incident light; anti-reflection treatment reduces the reflection itself, in order to reduce directly striking rays from lighting or the sun.

The reflection rate for the entire display in Liquid Crystal ViewCams has been reduced to 2.6 percent, by means of these reflection prevention treatments. This is nearly one-tenth of the current reflection rate, enabling real outdoor use of TFT liquid crystals. However, this is still considered unsatisfactory in terms of direct sunlight reflection on clear days. A reflection rate of less than 1 percent is a future goal.

Second Stage Line Achieves 300 Percent Productivity By Enlarging Substrates, Improving Processing Capacity: ***Yoshiaki Kobayashi, Toshiba Liquid Crystal Production and Technology Department***

Productivity of second stage TFT color liquid crystal mass production lines rose 300 percent over that of first stage lines (Figure 7).

There were many indications that first stage lines have a lot of problems; TFT array processing in particular. Although this is a process in which roughly one million transistors are incorporated into a 10-inch liquid crystal panel, the processing equipment is vastly inferior compared to LSI equipment (Table 3).

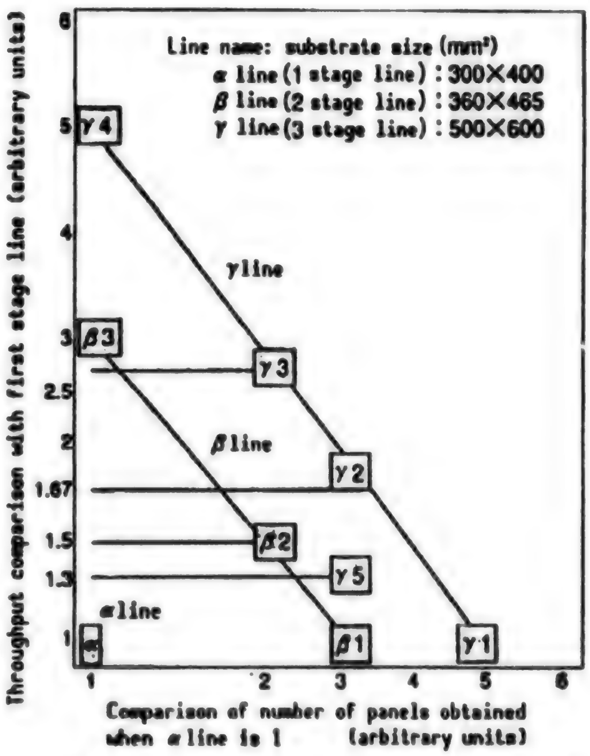


Figure 7. Approach for Achieving 300 Percent Productivity. Second stage lines are designated by the β line; in order to raise productivity 300 percent, it is necessary to combine the following: increases in the size of the substrate, improvements in equipment throughput, and reductions in the number of processing steps. The upcoming third stage lines, with 500 percent productivity indicated, are also shown.

Table 3. Problems With Equipment Used in First Stage Line Array Processing

The equipment used in first stage lines have some problems in terms of yield, productivity, energy consumption, and space. Equipment for making films in particular require a great deal of improvement. Small sheet equipment meant for second stage lines are being jointly developed with equipment makers, which will conserve resources, energy, and space.

Equipment Name	Low Operating Rate	Electrostatic Breakdown	Particles	Low Throughput	Energy Use	Space
Substrate Washer			X		X	
Films: CVD equipment	X		X	X	X	X
Films: Spatter equipment	X		X	X	X	X
Resist Coater		X	X			X
Exposure Equipment		X		X		X
Developing Equipment		X	X		X	
Etching/Peeling				X	X	X

Second Stage Lines Raise Productivity 300 Percent

The positioning of second stage lines can be considered manufacturing lines that run on each company's holdovers, as well as a way to expand the market for TFT color liquid crystals. By already overtaking and surpassing color CRT's place in the world in terms of cost and performance, the market for TFT color liquid crystals can be considered solid.

A goal of "building a line that raises productivity 300 percent" has been set for these second stage lines. An itemized breakdown shows that array processing, which has a high value of investment, shows a 300 percent improvement in the production index per unit of investment in equipment (Figure 8).

Next, cell processing, which is being put in a line format, shows a 300 percent improvement in the production index per hour. Module processing, with a large number of workers, shows a 300 percent improvement in the production index per worker. Here, the index of production is indicated by the number of panels taken per

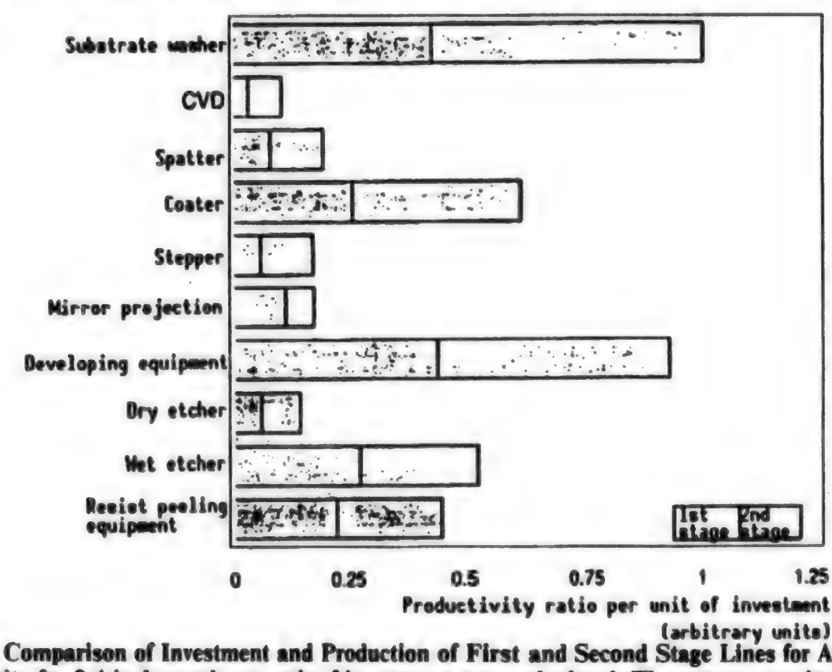


Figure 8. Comparison of Investment and Production of First and Second Stage Lines for Array Processing. The output capacity for 9.4-inch panels per unit of investment was calculated. The output capacity for each piece of equipment is shown when the output capacity of a substrate washer is set as 1. Productivity was raised 200-250 percent for investment in second stage equipment.

mother glass substrate and the product of the number of substrates treated per hour, the operating rate, and the yield. This is equal to the product of the number of panels treated per hour and the yield.

Advances in Glass Substrate Enlargement and Space Conservation

Actual measures that raise productivity 300 percent include: (1) creating a bigger glass substrate that doubles the number of 9.4-inch panels obtained, from two to four. Furthermore, (2) equipment that creates films, represented by CVD (chemical vapor deposition) and spatter equipment, was changed to small sheet equipment, which improves the operating rate, stabilizes performance, controls particles, improves maintenance, and lowers running costs. As a result, resources, energy, and space can be conserved.

(3) Improvements in conveyance methods which are at the heart of lithography processing, and improvements in line tact through reconsideration of treatment methods, were also important. In addition, (4) various kinds of inline inspection equipment such as optical pattern inspection devices and dust monitors were developed and introduced. These are indispensable tools for automatic completion of processing.

Furthermore, (5) CIM (computer integrated manufacturing), which includes monitoring process conditions and tracking lots, is actively used, and improves yield. Equipment that continues to have low completion rates require control of process condition fluctuations. During increases in the types of production, it is necessary to (6) automate cell and module process in order to raise productivity. Equipment has been developed that takes plan modifications into account, in order to respond to the many types of module processing.

Substrates Already Enlarged in Third Stage Lines

The 500 percent rise in productivity that the forthcoming third stage lines aim for will be achieved by: (a) increasing the substrate size, from two 9.4-inch panels to six; (b) improving equipment capacity by raising yield and by improving throughput by increasing tact time; and (c) reducing the number of processing steps, in order to reduce investments. The result of (a) would be a 300 percent increase in productivity, and (b) and (c) would each raise productivity 130 percent, which would give a concrete rise in productivity totaling 500 percent. In addition to these measures, the costs of parts and materials would also be reduced, in order to reduce total manufacturing costs.

Technical development and study of concrete policies have begun for third stage lines, based on the circumstances of developing equipment for second stage lines. Primary aims include: 1) Raising productivity with large substrates, 2) Reducing initial investment and running costs by effective use of clean rooms, 3) Reducing power and overhead costs of materials and chemicals, and recycling, 4) Reducing the number of processing steps and integrating processes, 5) Introducing low-cost processes and reducing equipment costs, 6) Improving equipment reliability and maintaining a high rate of operation, 7) Full development of CIM and AGV (automated guided vehicles), 8) Responding to the many types of cell and module processes

For second stage lines, the $360x465mm^2$ glass substrate size, which can give four 9.4-inch panels, was selected. The substrate size for third stage lines will change greatly, depending on which panel size is optimal.

Once development of the equipment used for the second stage line's $360x465mm^2$ substrate size was completed, equipment manufacturers began deciding on the substrate size for third stage lines, which will depend on when equipment meant for the substrate size selected can be developed. Panel makers must still address the question of which substrate size will be the next standard. $500x600mm^2$ is one candidate, but the change may be made with the $360x465mm^2$ size meant for the second stage.

Parts and Materials Technology: Technology for ¥ 50,000 Panels Cropping Up, Such as Unpolished Glass

94FE0297C Tokyo NIKKEI MICRODEVICES in Japanese Dec 93 pp 83-87

[Part 3 of three parts by Katsuhiro Nozaki; includes three contributed essays from corporate executives]

[Text]

Standardization of Each Type of Specification An Issue

TFT panel parts and materials, which resisted price cuts during the 1991-93 period, are moving in order to meet the ¥ 50,000 goal for 1995. In addition to the effects of mass production due to market expansion, we can expect drastic price cuts because of new technology. A 40 percent cost reduction in glass substrates is targeted, due to unpolished glass and non-anneal processing. Productivity will increase with a 40 percent reduction in color filter costs by introducing printing and electrodeposition methods. Progress is being made on cutting backlights to ¥ 2000 in 1994, by using a single light, made possible by raising transmissivity and making lamps brighter. And ways to increase added value, such as non-reflecting polarizing plates, have been discovered.

The prices for parts and materials for making second generation TFT color liquid crystal panels are changing in order to have ¥ 50,000 10-inch panels by 1995 (Figure 1). Panel makers have rushed into concrete ways to step up production. Parts and materials manufacturers, confident of market expansion, have finally moved to lower prices.

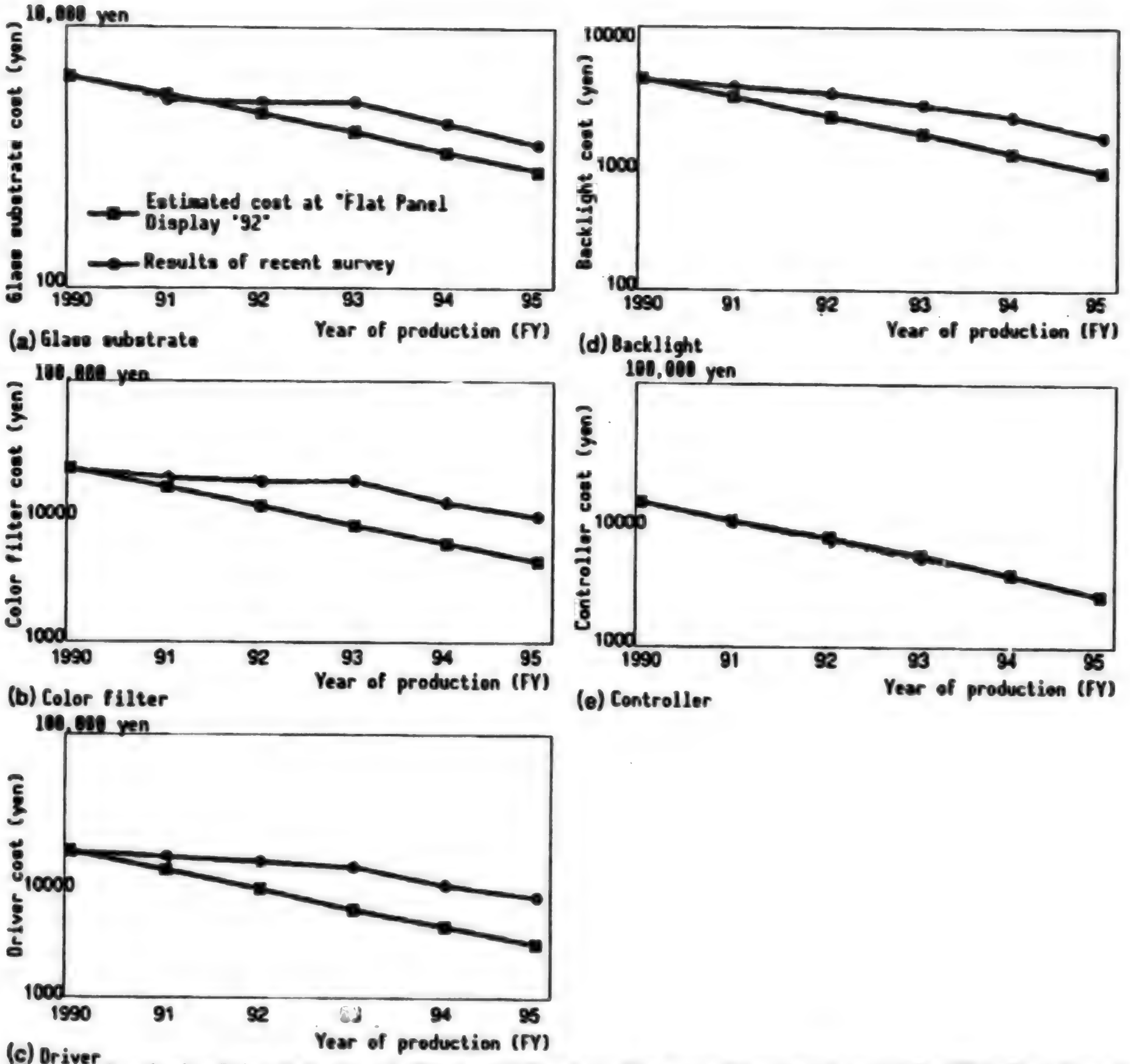


Figure 1. Continuing Price Reductions in Parts and Materials. The costs of parts and materials will begin to drop in 1994. Costs are finally changing after leveling off during the 1991-93 period. The effect of new technologies, such as unpolished glass substrates, printing methods for color filters, the introduction of electrodeposition methods, multiple driver LSI pins, and a single backlight, have been considerable. Estimates are based on a 10-inch panel size.

However, the ¥ 50,000 price cannot be achieved through the results of mass production alone. It requires development of new technologies in each field, which can lower costs. During 1993, each company engaged in trial production of parts and materials that embraced these new technologies, and most will continue production in 1994.

1. Unpolished Glass Substrates Pushed

The price of glass substrates began to change first. Reductions in cost resulted from shortening processes by creating non-abrasive glass, and increasing melting and shaping yield. As each company incorporated both of these measures, a goal was set for cutting the cost of 10-inch panels in half, from approximately ¥ 3000 in 1992 to ¥ 1500 by 1994-95.

Companies putting their efforts into unpolished glass are Corning, the largest glass manufacturer, and NH Technoglass. Corning already began mass production applications in the first part of 1993. This is because a flat, clean surface could be obtained right after shaping by improving melting and shaping methods. The company has already moved towards "application of an annealing

reduction process to mass production by the end of 1994" (Mr. Koya Iwai, Corning Japan Business Division's Planning and Management Section Chief). Costs can be cut 40 percent overall. NH Technoglass can begin mass production by Spring 1994 if work on unpolished glass is hurried.

Nippon Electric Glass finds raising the yield of melting and shaping "effective in lowering costs" (Mr. Takao Sakaki, Nippon Electric Glass Managing Director and Technology Chief). The current yield of 50 percent or less can be raised to 60-70 percent. A multihead furnace for melting and shaping was developed for this. This is different from the currently used small furnaces, which are specific to each type; because this is a large furnace meant for all types, the surface area in contact with the furnace walls is small, and defects are rare.

A movement to introduce new methods for color filters, such as the printing method (refer to p 85) and an electrodeposition method, has emerged. A 40 percent reduction in manufacturing costs is targeted. The current ¥20,000 cost for the 10-inch class will be "¥7000 by 1995-96" (Mr. Masatake Nagao, Dai Nippon Printing Company Managing Director). Use in mass production will begin during 1994. There is also a trend towards "reducing costs with the color dispersion method" (Toppan Printing Company Electronics Division). By reducing parts and materials costs and the amounts used, and raising yield from the current 60 percent to 80 percent by making the product cleaner, color filters will comprise 10 percent of panel costs by 1995.

2. Advances in Creating a Single Light Backlight Unit

Cost reductions in backlight units are planned; the approximately ¥3000 for the 10-inch class will drop to less than ¥2000 during 1994. Progress is continuing for reliance on a single light for the entire unit. Improvements in unit transmissivity and lamp brightness have been very effective; costs "can be cut 30 percent" (Mr. Masahiro Tomatsu, Fujitsu Chemical Technology Section Chief) by using a single light.

Most light-conducting plates have shifted to the shaping method. Mass production applications have already begun for small 4-inch panels. Ten-inch plastic products "will also enter the market during 1994" (Mr. Hiroichi Matsui, Meitaku Systems Representative Managing Director). But because production efficiency is low, "lots will be combined to give the effect of large volume production" (Mr. Yutaka Kikuchi, Empress Optonics Division Backlight Technology Development Section Chief) by standardizing sizes and shapes. There are also manufacturers that omit the light-conducting plate (refer to p 86).

Progress is being made on giving the polarizing plate, which controls the transmissivity of the entire panel, a higher added value with lower reflectance (refer to p 87).

However, cost reduction through introducing coating methods is a problem, because the unit value jumps 3-10 times.

40 Percent Reduction in Production Costs Targeted Through Introducing Printing Methods; Reducing Costs of Flat Panels an Issue: *Takanari Hamaguchi, Dai Nippon Printing Microproducts Division*

A 40 percent reduction in color filter production costs is the goal, by changing the manufacturing method to a printing method.

The characteristics and costs of the printing method have been compared with those of the currently popular color dispersion method (Table 1).

Table 1. Features of Printed Color Filters

A color filter manufacturing method, the printing method is compared with the currently used color dispersion method on the basis of characteristics and costs. The printing method is still inferior to the color dispersion method in terms of quality, but in terms of production, there are a number of superior features.

Item		Printing method	Color Dispersion method
Product Quality	Spectral Characteristics	Good	Good
	Resolution	Fair	Good
	Measured Pitch Precision	Fair	Good
	Surface Configuration	Fair	Good
	Resistance to Heat, Light, and Chemicals	Good	Good
Process Equipment	Equipment Costs	Good	Fair
	Number of Processes	Excellent	Fair
	Materials Costs	Good	Fair
	Ability to handle large substrates	Good	Fair-Good

At the present time, the printing method is inferior to the color dispersion method in terms of quality and precision, but its ability to lower costs when mass production capability is taken into consideration is excellent. The offset methods are currently the most popular, and planographic and intaglio offset methods are now being applied (Figure 2).

In terms of precision, the printing method can resolve a pattern of 15-30μm, but some problems remain in terms of measurement stability for each printing, and pattern linearity. If the line width is 100 μm, precision within 8 percent can be ensured. Furthermore, because printing is done through a rubber-like blanket in the offset method,

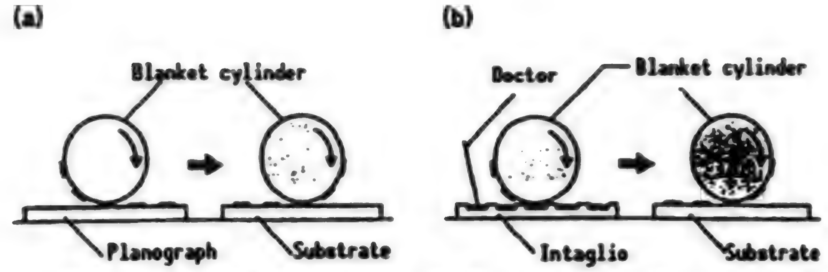


Figure 2. Conceptual Diagram of Offset Printing Methods. The offset method is currently the mainstream printing method. (a) shows the planographic offset printing method, and (b) shows the intaglio offset printing method. These are already being utilized.

the transfer pattern expands and contracts in the direction of rotation. Applications for micropatterns is still difficult, because pitch precision changes several dozen µm/400mm.

There is also a problem with the cross-section of the stripe pattern becoming semi-cylindrical. This is being dealt with by using a roll after RGB (red green blue) printing and flattening, polishing, and applying an overcoat layer. In terms of quality, there are problems with external defects such as bumps, blemishes, and pinholes. Because these arise from the printing process, materials, and printer motion, they will be addressed by raising precision.

Lowering Costs With Parts, Materials, and Standardization

In terms of reducing costs: (1) The number of processes increases because flattening the surface shape is necessary; as a result, cost increases and yield decreases are a concern. These are addressed by standardizing ink materials and lowering the cost of treatment methods. (2) In addition, general improvements in processing, materials, and printer precision will be made in order to address defects, which affect yield. (3) Pushing for standard glass substrate size and characteristics is necessary. Substrate size is becoming uniform in second stage lines, but spectral characteristics and film thickness differs from one panel maker to the next. Standards are desired from the panel maker leadership. (4) Reducing black matrix costs is also important. There is a need to work towards reducing the costs of all color filters through combination with a low cost black matrix.

Development of a Backlight Without a Light-Conducting Plate; Slimmer, Lighter, Cheaper: *Ken Kojima, Chadani Industries SBC Division*

We seek to develop a new backlight unit, in order to meet the strict demands of low power consumption, a thin and lightweight profile, and low cost. In order to do so, we intend to reduce costs by making them slimmer and lighter, and by simplifying the structure, through developing a structure that puts the light-conducting plate on the outside. This also shortens production processes, because the light-conducting plate's dot pattern printing process is omitted.

A backlight unit with the light-conducting plate on the outside is created from a cold cathode tube on a reflecting plate with a diffused reflection layer at the side of the unit (Figure 3).

The light emitted from the cold cathode tube is diffusely reflected within an air layer by the diffused reflection layer. The diffused reflection layer within the reflecting plate is created with irregularities due to embossing and a special highly concentrated ink.

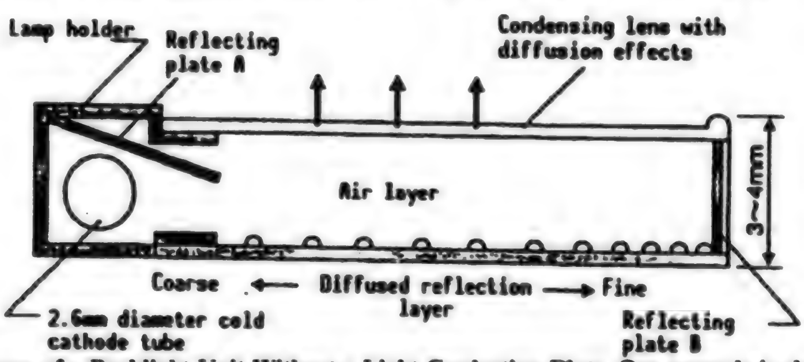


Figure 3. Structure of a Backlight Unit Without a Light-Conducting Plate. One example is shown. The diffused reflection layer is coarse near the lamp, and becomes finer the farther away it is. A condensing lens with diffusion effects is used at the same time.

Item	Structure: Flat	Heteromorphic	Light conducting plate removed (Air layer)
Unit weight (g)	110~130	70~75	40 or less
Unit thickness (mm)	4.5	4.5~1.5	3~4
Brightness (cd/m²)	1500~2500	1800~2500	2500~3000
Cold cathode tube (mm) (external diameter/internal diameter)	3/—	2.6/1.7	2.6/1.7
Power consumed (W) [STN]	3 or less	3 or less	2.8 or less
Power consumed (W) [TFT]	2.5 or less	2.5 or less	2 or less

Table 2. Features of Each Type of Backlight Unit. If the light-conducting plate is removed, the units are not only thinner and lighter, but light is used more efficiently as well. The weight is one-third and the thickness two-thirds of units currently used, and brightness improves 20-40 percent.

The backlight surface is brighter near the cold cathode tube than in other areas due to the directly emitted light. This causes a uniform reduction of brightness on the surface and the formation of bright lines. For this reason, a semi-transparent or opaque reflecting plate is installed near the cold cathode tube.

Light scattered at the underside of the diffused reflection layer is condensed with a special condensing lens at the top. The condensing lens is composed of one or two pieces. The lens used in trial tests is less directional than the prism lens film currently in use, and has the condensing ability and light dispersion of a diffusion plate.

Besides being slim and lightweight, backlight units without light-conducting plates can reduce light attenuation due to the light-conducting plate. Approximately one-tenth of the light coming from the cold cathode tube can be obtained as the backlight unit's surface brightness. These backlight units are one-third of the weight and two-thirds of the thickness of units currently in use. Brightness can be increase 20-40 percent, and energy consumption can be lowered 10-20 percent (Table 2).

In cases where brightness is at the same level as in units currently used, power consumption can be reduced to 1.5W or less in TFT panels and 2.5W or less in STN panels. Here, the transmissivity of the TFT panel is assumed to be 6 percent and the transmissivity of the STN panel is assumed to be 3 percent. We intend to utilize these backlight units without light-conducting plates by Fall 1994.

Reflectivity of Polarizing Plates Reduced to One-Tenth With Vaporization Multicoat: ***Tadashi Matsuo, Polartechno Technology Section***

Giving an anti-reflection coating to a polarizing plate reduces loss of transmitted light and prevents scattering of the light on the picture by reflected outdoor light. In ordinary glass plates and polarizing plates, a surface reflection of about 4 percent arises each time light penetrates the air interface. If we add the outdoor light x

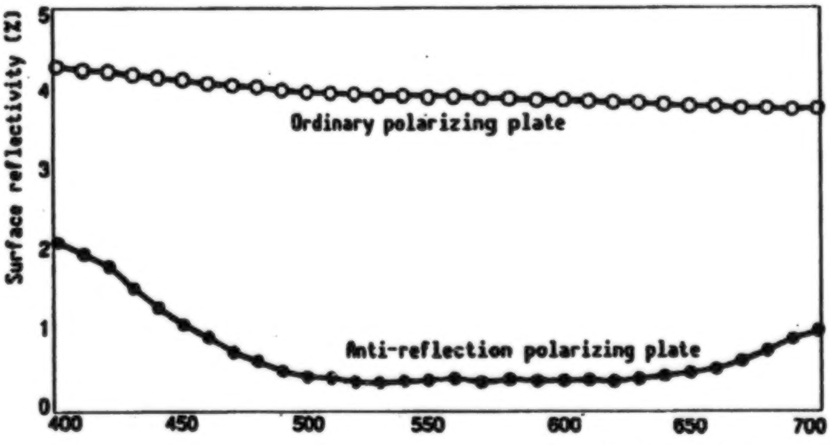


Figure 4. Surface Transmissivity of Anti-Reflection Polarizing Plates. Reflectance is cut to one-tenth with an anti-reflection coating.

4 percent reflectance to the light on the picture, readability drops dramatically. One criteria required for outdoor use is a surface reflectance of 0.4 percent or less, which is one-tenth of the reflectance of ordinary polarizing and glass plates (Figure 4).

Methods for creating anti-reflection can be categorized as the vaporization multicoat method and the applied coat method. In the vaporization multicoat method, substances with different refraction rates form a layer on the film surface by means of vaporization within a vacuum. This method gives the lowest surface reflectance. This technology was primarily established for plastic products such as optical parts, but low productivity and high costs due to batch methods are obstacles. Inorganic compounds with different refraction rates such as SiO_2, TiO_2, and ZrO_2 are made into films with thicknesses ranging from 0.1-0.2 µm, which correspond to one-fourth of the respective wavelengths of visible light.

In the applied coat method, a substance with a low refraction rate is applied to the polarizing plate and the supporting film. This is suitable for continuous roll film processing, and is a technology meant for mass production. It is also cheaper than the vaporization method-.However, it is somewhat inferior to the vaporization method in terms of features such as surface reflectance and hardness. Materials used include organic and inorganic fluorine compounds.

Development is continuing on a direct and an indirect processing method for creating films. In the indirect method developed first, an anti-reflection process was administered onto the transparent hard coat supporting film. An anti-reflection polarizing plate was created by sticking this film onto the polarizing plate with an adhesive. The direct method puts an anti-reflection coating directly onto the surface of a hard coat polarizing plate. It is suited for thin items, and shortens the production process, therefore giving cost advantages.

Fingerprints sticking to the surface is a problem with anti-reflection processing (Table 3). A smudge-preventing effect is obtained by giving the outer surface of the film a water repellant treatment with a vaporization or dipping method. However, a surface that resists fingerprints completely cannot be attained under present circumstances.

Table 3. Required Characteristics of Anti-Reflection Coating, and Current Level of Performance

0.4 percent or less can be achieved with the vaporization multicoat method, but even greater reductions in reflectance are necessary for outdoor use. *1 indicates ultra-micrograde.

Characteristics	Required Performance Criteria	Current Performance
Surface Reflectance	0.4 percent or less	0.2-0.4 percent—vaporization multicoat; 1.0-1.5 percent—applied coat of a low refraction substance
Surface Hardness (scratch resistance)	Steel wool "0000"*1; no scratches with a 250 g/cm load	2H and up with pencil hardness; no surface scratches
Adhesion	Base test and cellophane tape; no peeling with the peeling test	OK without peeling
Fingerprints	No fingerprints; tentative goal of tangent angle (water)$\theta > 100°$	$\theta > 100°$ possible with a water repellant treatment but fingerprints remain

Foreign Broadcast Information Service (FBIS) and Joint Publications Research Service (JPRS) publications contain political, military, economic, environmental, and sociological news, commentary, and other information, as well as scientific and technical data and reports. All information has been obtained from foreign radio and television broadcasts, news agency transmissions, newspapers, books, and periodicals. Items generally are processed from the first or best available sources. It should not be inferred that they have been disseminated only in the medium, in the language, or to the area indicated. Items from foreign language sources are translated; those from English-language sources are transcribed. Except for excluding certain diacritics, FBIS renders personal names and place-names in accordance with the romanization systems approved for U.S. Government publications by the U.S. Board of Geographic Names.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by FBIS/JPRS. Processing indicators such as [Text] or [Excerpts] in the first line of each item indicate how the information was processed from the original. Unfamiliar names rendered phonetically are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear from the original source but have been supplied as appropriate to the context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by the source. Passages in boldface or italics are as published.

SUBSCRIPTION/PROCUREMENT INFORMATION

The FBIS DAILY REPORT contains current news and information and is published Monday through Friday in eight volumes: China, East Europe, Central Eurasia, East Asia, Near East & South Asia, Sub-Saharan Africa, Latin America, and West Europe. Supplements to the DAILY REPORTs may also be available periodically and will be distributed to regular DAILY REPORT subscribers. JPRS publications, which include approximately 50 regional, worldwide, and topical reports, generally contain less time-sensitive information and are published periodically.

Current DAILY REPORTs and JPRS publications are listed in *Government Reports Announcements* issued semimonthly by the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161 and the *Monthly Catalog of U.S. Government Publications* issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

The public may subscribe to either hardcover or microfiche versions of the DAILY REPORTs and JPRS publications through NTIS at the above address or by calling (703) 487-4630. Subscription rates will be provided by NTIS upon request. Subscriptions are available outside the United States from NTIS or appointed foreign dealers. New subscribers should expect a 30-day delay in receipt of the first issue.

U.S. Government offices may obtain subscriptions to the DAILY REPORTs or JPRS publications (hardcover or microfiche) at no charge through their sponsoring organizations. For additional information or assistance, call FBIS, (202) 338-6735, or write to P.O. Box 2604, Washington, D.C. 20013. Department of Defense consumers are required to submit requests through appropriate command validation channels to DIA, RTS-2C, Washington, D.C. 20301. (Telephone: (202) 373-3771, Autovon: 243-3771.)

Back issues or single copies of the DAILY REPORTs and JPRS publications are not available. Both the DAILY REPORTs and the JPRS publications are on file for public reference at the Library of Congress and at many Federal Depository Libraries. Reference copies may also be seen at many public and university libraries throughout the United States.

END OF

FICHE

DATE FILMED

16 AUG 94